TINY HOUSE SYSTEMS DEMYSTIFIED

Planning for Water, Waste, Cooking, Food Storage, Heating, and Cooling for your Tiny (or not tiny) House

Contents

CONGRATULATIONS!

- Key Subjects

ABOUT THE AUTHOR

- Expertise
- Something Personal

TINY HOUSE SYSTEMS SELECTION

- How will you be using the systems?
- Cooking style?
- Are you living alone or with others?
- What level of modern conveniences do you want / need?

TINY HOUSE FOOD STORAGE AND PREPARATION SYSTEMS

- Food Storage
  - *Root Cellars*
  - *Spring Houses*
  - *Refrigerators*
  - *Freezers*
- Cooking

TINY HOUSE WATER SYSTEMS - PART 1

- Water Supply
- Hot Water Systems

TINY HOUSE WATER SYSTEMS - PART 2 - WASTE WATER SYSTEMS, WINTERIZATION, AND OTHER WATER RELATED ISSUES

- Waste Water Systems
  - *Black Water and Grey Water*
- Winterization concerns
  - *Running Water*
  - *Heat*

Insulation

TINY HOUSE COOLING SYSTEMS

Passive Cooling

Ceiling Fans

Window / Floor / Desk Fans

RV-style Roof Vent Fans

Active Cooling

Window Units

Through wall, Hotel-Style Air Conditioners aka. Packaged Terminal Air Conditioners (PTAC)

Roof Mounted, RV-style Air Conditioners

Mini-Split Systems

TINY HOUSE HEATING SYSTEMS

Insulation

Active versus Passive Heating

Active Heating

Direct Active Systems

Indirect Active Systems

Backup Systems

CONCLUSION

Congratulations!

By buying this book, you realize that to successfully build a house (tiny or not so tiny) with a minimum of problems requires a good deal of pre-planning.

Key Subjects

This book will provide you with an overview of the various systems you need to consider when planning your tiny home.

- Food Storage and Food Preparation Options
- Water and Waste Options
- Heating Options
- Cooling Options

I hope that this book helps you think through the different systems that you need for your house, tiny or otherwise, allowing you to best determine what will fit your individual needs.

Tiny House Systems Selection

Some of the most important items that Tiny House denizens should choose for their house are the appliances and various systems within their house. But before you run off to the nearest home improvement or appliance store, first step back and consider what you truly need in your tiny house. What type of commode, hot water system, cooking appliance, cool/cold food storage, and depending upon your chosen locale, air conditioner (trust me, in the hot-humid climate of the southeast United States, AC is almost a necessity) or heater (conversely, up north, heat is much more a consideration)?

Each of these individual appliance choices are worthy of their own chapter, but for now I will touch on some of the primary considerations that should be made, common to all systems.

How will you be using the systems?

A tiny house set up (semi-)permanently on a piece of land will require different systems than one that is designed to be used more like a recreational vehicle / camper. If you are travelling and using your tiny house like a camper, you will probably want to have water supply tanks and if not wanting to dump waste water on the ground, holding tanks incorporated into the design, along with having storage for the various hoses (both supply and waste) needed for hooking up at a camp ground or in someone's back yard. Another consideration is whether you have sewer or septic connections available to you.

Cooking style?

Photography: Sharon Brewer Photography, Styling:: The Architect's Wife

If you are a very sociable person, who enjoys having people over for dinner all the time and cooking for them, or happen to be a gourmet cook, or both, your needs will be different from someone who prefers to eat simply and in solitude. Especially if they prefer microwave meals to cooking on a stove.

Are you living alone or with others?

Single guys (and girls) may require less space...

This all boils down to volume. One person requires less food, supplies, and water than a family of four, and generates more waste (both trash and biological). The more that needs to be on hand and stored, the more room that needs to be allocated to said storage, and the more waste that will be generated that will need to be dealt with. Of course, your particular eating habits also will play a part in this, as will your skill (or lack thereof) in cooking.

What level of modern conveniences do you want / need?

Simplest option

Some people can be truly happy with a simple bucket with a pool noodle on the rim and a bucket of dry sawdust, while others will demand a flush commode connected to a holding tank / sewer / septic field. Some can be happy with a solar camp shower hung from a tree, others prefer a more traditional indoor shower, while others cannot live without a soak in their bathtub. Some are happy with heating water on a stove or campfire, while others cannot do without a hot water system just like in a typical house. Some will require a hook over a campfire, while others will be happy with a hot plate and microwave on a counter, while others will demand a full stove with oven, that simply must use gas.

None of the above choices are inherently wrong, as each person has their own level of comfort and modern conveniences that they require, but the choices made will inform as to what systems need to be included in your tiny house.

Tiny House Food Storage and Preparation Systems

Of the various and interrelated systems in a tiny house, one that deserves a lot of attention is the various means of storing and preparing food. As always, there is no one true answer as the needs of the people living in the house will dictate the proper solution. So let’s delve into the sorts of decisions that need to be made when planning for food storage and preparation!

Food Storage

Food storage, both dry and cold, is a matter of volume versus frequency. The more frequently you shop (at a store or in your garden) the less you need to store at any one time. If you are the type that goes to the store once a month and stocks up, you will need more storage space for your food. Also, the number of people being fed will have a definite effect on volume. Dry food storage typically consists of shelving and cabinets. I say typically, because some supplies just need a nail and a handy rafter. ;-) Be sure and plan for plenty of storage in your tiny house, and don't be surprised if there is never enough, it is just like closet space in that respect. Cold storage again depends upon the volume and frequency of what is being stored. In modern life, cold storage equates to a refrigerator. However, there are older technologies that can be utilized in a permanent location with a bit of preparation, such as root cellars and spring houses.

Root Cellar

Root Cellars are nothing more than holes dug in the ground and covered, with the

purpose of utilizing the steady state temperature of the earth. The goal is to dig down to below the frost line, which depending upon your latitude on the earth can range from the surface near the equator to 6 feet (2 meters) or more near the poles! The earth's temperature at that depth is typically between 55 and 57 degrees Fahrenheit (13 to 14 degrees Celsius). A root cellar is typically finished out with walls and a floor, mostly to keep the sides from crumbling down into the cellar. They can be sizable rooms with an earth covered roof, or just be a hole with a cover.

Spring House in Cades Cove, Great Smoky Mountains National Park

Spring Houses are similar in function to root cellars in that they use nature's coolness to keep food stuffs cool. They are small houses typically built over a spring or cold stream. The cold water is channeled through the house, and food is typically kept in pottery placed into the running water, or on shelves above the water such that the coolness from the cold water that keeps the air in the spring house cool, also keeps the stored items cool.

Refrigerators

Koolatron 29 Quart Voyager Thermoelectric 12-Volt Cooler

Modern civilization makes use of refrigerators and freezers to keep food cold. In a tiny house, space is at a premium, and your huge double door fridge with all the bells and whistles takes up a LOT of space. So go ahead and be honest when you figure out just what you need to keep cool or cold. Are the only things you keep in your fridge a gallon of milk (sometimes turned), cans of Mountain Dew and leftover pizza? You might be able to get by with something quite smaller, such as a travel refrigerator.

The majority of tiny houses will use a compact refrigerator, often termed a dorm refrigerator. Aside from the capacity of the refrigerator, one of the primary concerns that needs to be considered is the manufacturer recommendations on installation clearances in an enclosed space. Take a look at the user manual for the model you are considering. Look for information on proper air circulation or choosing the right location.

Haier 4.0 Cubic Feet Refrigerator / Freezer

For instance, the Haier model above states in its user manual: "THIS REFRIGERATOR SHOULD NOT BE RECESSED OR BUILT-IN IN AN ENCLOSED CABINET. IT IS DESIGNED FOR FREESTANDING INSTALLATION ONLY." This does not mean you cannot have it underneath a counter, rather it means that you cannot have the cabinet flush up against the body of the refrigerator where there is no airflow around it. If you read further down in the manual, the recommended clearances are given:

- Sides……3/4" (19mm)
- Top.....2" (50mm)
- Back.....2" (50mm)

When doing your space planning in your kitchen, you need to ensure that there is at least that much space around the refrigerator. Some manufacturers recommend as much as 5 inches at the rear and as much as 3 inches to the sides and top, so research and be aware of these requirements before purchasing. Other considerations are whether or not the refrigerator has a freezer section. Some do, some don't. Only you know what your needs are, but be aware, the majority of them that do have freezer sections are tiny, having only enough room for maybe two or three frozen meals at a time.

Midea 5.0 Cubic Feet Chest Freezer

Freezers are another solution for those who need more freezer space. There are two types, upright (door on the front) and chest (door on top). Of the two, the chest style is the most efficient. This is because cold air sinks lower and hot air rises. In a chest style, you open the top lid, and the cold stays in the chest. In an upright style, you open the door and the cold spills out of the bottom as the warmer air goes in a the top, requiring the freezer to work harder to cool the air inside back down when you close it.

Norcold N641 3 Way 2 Door Refrigerator / Freezer for RVs

The above are options available from the home supply and department stores, but there is another option available, which is to look at RV suppliers. The RV market has a number of options available that are perfect for tiny houses, to include refrigerators and freezers designed to be installed into cabinetry with zero clearance on the sides and capable of running off of 120 volt AC, and propane gas (two way) or 12 volt DC, 120 volt AC, and propane gas (three way). Like everything, the more features or the more specialized, the more expensive.

To see what I mean, check out the linked to 3-way (gas / 12 v DC/ 120v AC) refrigerator with top freezer. It is expensive, but might be worth it to you. You can even get them with ice makers built in!

Cooking

Just like with food storage, there are many options available for a tiny house resident when it comes to cooking. These range from a campfire to a full-blown stove and oven, and everywhere in between. Also like with food storage, it is the need of the inhabitants that determine what is needed. If all you eat is frozen meals, a microwave is preferable to a stove. If you LOVE to grill, maybe a propane or charcoal grill with a side burner outside will be of better utility. If you like to bake, an oven is a must. It is up to you to determine what your needs are and plan accordingly. Although of interest to the discussion, I will give only mention of campfire cooking and grilling out, as the ins and outs of those methods could fill a blog for years to come. Instead, I will focus on the cooking appliance options available for installation in a tiny home.

Proctor Silex 34202 Double Burner

Many people have determined that they do not need anything more than a hotplate and a microwave to prepare their meals. There are loads of counter top burners available out there like the one to the left, and you can (as always) spend more for quality and features. Although, at its most basic, a single electric burner will fit the bill, most people that go this route opt for a double burner style.

You (of course) have your pick of aesthetics, and a popular option is an induction style cook top due to their smooth, clean lines. Be aware that you can only use cast iron or stainless steel cook wear with them without having an adapter due to the way that they work. They work by running alternating current electricity through a coil under the burner surface, that creates, or induces, an oscillating magnetic field in the pot placed on the burner.

BergHOFF Two Element Induction Cook Top

This magnetic field created in the pot or pan causes the metal to heat up, thus cooking your food. Some primary benefits of an induction burner are that it is more energy efficient than a traditional resistance style burner, it allows instant control of the burner allowing for more precise cooking, and due to the way that it only heats the pot, the underlying surface only heats up from contact with the heated pot, which significantly reduces the risk of burns, Also, as the pot itself is all that is heated, the air surrounding the pot is not directly heated the way it is with resistance electric or gas burners, which is more efficient and less of a heat source for your air conditioning to work against.

12 inch electric 2 burner countertop insert by Summit Appliance

For about the same real estate on your counter top, you can go to a counter top insert. Yes, they are more expensive, but as a built in, there is less danger of it becoming a projectile when you go over a bump. Not to mention, they look better and leave your counter top less cluttered. These are available in gas or electric models, and, as always you can spend as much as you want for one.

Of course, when looking at countertop inserts, you can go as large and as fancy as you want. Any of the larger models that are available for your standard house kitchen will work in a

tiny house, it is merely a matter of deciding how much counter space you wish to give up.

If you need an oven however, there are two options available. You can make room for a standard size stove with oven, or go for one made for an RV. The standard household stove with an oven comes in many sizes, styles, and flavors, and if you need the cheapest option, just keep an eye out on your local Craigslist, where you can often find one for free or a minimal amount.

Atwood Wedgewood 21 inch 3 burner LP stove with oven

The RV style stoves with ovens typically come in gas, set up for propane use. They are smaller than your typical stoves with ovens, which is both a good and a bad thing. Good, in that it fits into your tiny house better; bad, in that it limits the size of the thanksgiving turkey you can cook. Linked is a 21-inch version, with 3 gas burners. I consider it a good compromise between size and utility, and use this version in the majority of my designs that do not have room for a standard home style stove with oven.

Panasonic Genius 1.2 Cubic Ft 1200 Watt Microwave

Microwaves, as you know, come in all sizes, colors, and capacities. For a tiny home, as always, the space taken up as opposed to the utility provided is a needed consideration to be

decided upon. Some are designed to mount over the stove and provide a vent hood function, which may be a consideration for you. Ultimately, it is a matter of your preference, size, and feature requirements.

Mr Coffee ECMP50 Espresso Maker

I would be remiss in mentioning appliances for a tiny house without mentioning what many feel is the most important of all, the coffee maker! Now I will not attempt to state which one is best, as no one wins that argument, but I will state the one that for us, is the best combination of price and function, providing a great cup of espresso at a relatively inexpensive price. This is the Mr. Coffee ECMP50 Espresso/Cappuccino Maker. It combines the best of the traditional coffee maker with a pump driven espresso machine. There is a water reservoir in the rear, and it has a milk frothing wand that works, but gets dirty quickly. However, the quality of the brew is excellent, and has ruined me for regular drip style coffee. My wife and I brew into (and fill) a standard coffee cup with no issues.

My one caveat for you to consider when it comes to small, counter top appliances is that you need to ensure you have the electrical outlets available for them, as well as a place to store them or a means to secure them while moving the tiny house. Ultimately, planning out what you want and need is paramount in deciding what sort of space and hookups you need.

As you can see there are a lot of options to be considered when selecting the food storage and preparation systems for your tiny house. But the more decisions you can make up front, the better satisfied you will be when you are living in your tiny house.

Tiny House Water Systems - Part 1

"Water, water, every where, Nor any drop to drink." SAMUEL TAYLOR COLERIDGE, THE RIME OF THE ANCIENT MARINER

Water is a necessity of life, but providing for it in a tiny house can be challenging. The options range from hooking up to utility provided water, to collecting and filtering rainwater on-site, to lugging it all in from elsewhere in jugs / barrels / goatskins / buckets / coolers / canteens / etc...

Jug of water over pan

The simplest solution is to have a jug of water with a spigot over a catch basin. Simple, to the point, limited only by the amount of water you are willing to haul in (in jug-full increments). Heating is external to the system (unless you put the jug in the sun), and coldness depends on the ambient temperature (or liberal applications of ice). Dirty water is thrown out on the ground, just don't throw the baby out with it!

Hauling water is hard, just ask Mickey!

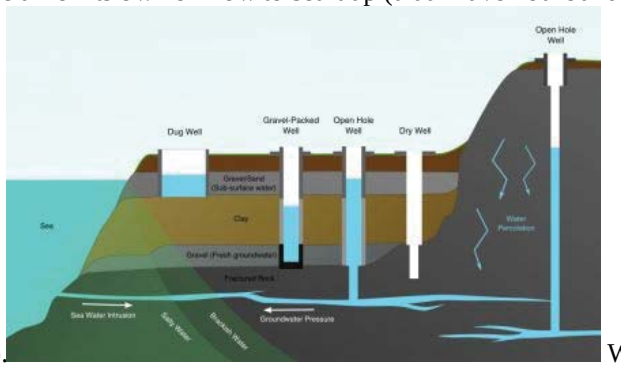
Of course, there are downfalls to this system, namely heating the water can be problematic, there is a limited supply, and hauling it all gets tiresome after a while. In many countries, the tap water is not considered safe to drink, and you have to buy water at the store in 5 or 10 liter containers. In some cases, a home will have a cistern, and pay to have a company send a water truck out to refill the cistern on a regular basis.

Water Supply

Aside from carrying water in from off-site, there are many options available on-site, depending upon the locale. These range from a clear mountain stream, to a well, to rain water cistern, to a municipal water system. All have advantages and drawbacks to be considered.

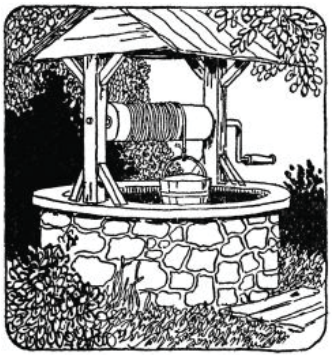
a crisp drink from a stream

If you are lucky to be distant from civilization, you may have the luck of having access to a nearby stream with clean water. Now, although it may look crystal clear and perfectly harmless, there are potential risks involved that I would prefer you hear from **others more learned than I about**. I neither advocate for nor against drinking straight from a stream, it is merely an option to be considered. In the event that you have determined that the water is safe to drink, there exists the need to bring the water to your tiny house in a usable fashion. This can be done either using gravity or via a pump. Both require similar equipment, although gravity fed requires larger pipes and a source that is a fair elevation above your tiny house. Here are s**pecifics on how to set up a pump version**, the gravity fed system will be similar, but it also is an article all of its own on how to set it up (that I have not found a neat little link to like the above yet).



Water Well types

Another option is a well. As you can see above, there are a number of different types. The dug well is the traditional version from antiquity. Typically dug through the use of hand tools or with a backhoe today, a dug well is still common in many parts of the world. The well is dug down to below the water table, continuing to dig until the water coming into the well exceeds the rate at which the digger(s) can bail the water out of the hole.

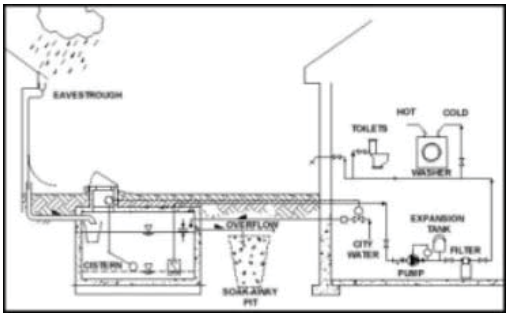


Dug stone well, with cover and windlass to lift water bucket

To prevent sidewall collapse, a lining of stone, brick, tile, or other material was installed. Some sort of protection was built at the entrance to protect from items falling into the well, including runoff from rain. As shown in the illustration to the right, for most European cultures there is typically a windlass with a bucket attached with which to draw up the water. Dug wells have their drawbacks, in that they rely on the water table remaining at a level that allows water to be removed from the well. This water table naturally fluctuates with the amount of rainfall a region gets, and it is not unusual for a well to dry up in times of drought. Dug wells also have the drawback of being really easy to contaminate. The water table that these wells tap into is the sub-surface water, which collects all of the contaminants that are washed into streams and percolates into the ground. This includes pesticides, fecal matter, dead and decomposing animals, oil, trash, etc. Nowadays, the most typical type of well is dug using a drilling rig similar to that used in drilling for oil. They typically bore a 6-inch hole 100-400 feet into the bedrock, intersecting fractures in the rock that carry water. By law, at a minimum the top 18 feet of the bore must be cased with either a plastic or metal sleeve. Once the well is drilled, a submersible pump is lowered into the well, which pumps the water up to the surface.

A modern well, showing the pressure tank. Note that the well pump is actually a submersible style at the bottom of the well bore, shown to the right in the picture.

In most homeowner type installations, there is a pressure tank at the surface that is maintained at a certain pressure by the pump which provides the water pressure in the pipes in the home. In colder climates, this a well house (not shown) is built around the well and pressure tank to provide protection from the weather as well as providing an enclosure that can be heated to keep the above ground pipes and tank from freezing. The pipes are run to the house underground, typically by trenching down to below the frost line in the area (6 inches to 6 feet, depending on how close to the poles you are) and then back filling the trench once the waterline is installed. As the power that runs the well is typically supplied from the house, it is not uncommon for the power line to be placed in the trench as well, either within a conduit or using a type of wire that is rated to be buried underground.



A typical rainwater harvesting set up

Rainwater Harvesting is another historical option. Does your tiny house have a metal roof? Do you have space to place a cistern (tank) in which to store the captured water? Then you may be able to harvest rainwater to supply your tiny house. Calculating the amount of water you can harvest in a year is simple: **Maximum Annual Gallons of Rain Capture = Annual Rainfall x Square Footage of Roof x .623 Gallons** If you are curious why you multiply by .623, that is how many gallons are in an area of one square foot by one inch deep of rainwater. For instance, an 8 foot by 16 foot tiny house has a conservative minimum roof surface of 128

square feet. In Huntsville AL (where RidgeRunner Tiny House is located) the annual average rainfall is 54.34 inches. so using the above equation: Annual Rainfall: 54.34 x Square Footage of Roof: 128 x .623 Gallons = 4,333.29 gallons maximum annual gallons of rain capture. But this is what you would capture in an ideal world. Depending upon the type of roof you use, some water is lost due to evaporation or absorption. The typical rainwater capture efficiencies for roofing materials are as follows:

- For a tile or metal roof, use a 95% efficiency factor
- For a concrete or asphalt roof, use a 92% efficiency factor
- For a bare soil roof, use a 75% efficiency factor
- For a gravel roof, use a 70% efficiency factor
- For a grass roof, use a 17% efficiency factor

So, if our hypothetical 8 x 16 tiny house example above uses a metal roof, it would actually be able to capture 4,116.62 gallons a year. However, before you rush to install a rainwater harvesting system for your tiny house, you need to realize that in a typical household, a typical person will use an average of 50-100 gallons of water **per DAY**. This may seem high, but if you take a bath or a typical shower, the gallons quickly add up. This means that even if you are so efficient that you use 20% less than the lowest typical person (40 gallons a day) a entire year's worth of water in Alabama captured from the roof of our example tiny house would only last one person approximately 103 days, less than 1/3rd of a year. So unless you have a shed that is over twice as big as your tiny house that you can use to supplement your supply, you will need to consider other options (unless you live in a rain forest). Also, you need to realize that there may be regulations concerning water harvesting in your area. In some parts of the Western US, it is actually **ILLEGAL** to harvest rainwater on your own land. No, seriously! Specifically, it is still against state laws to harvest rainwater from a roof in **Colorado**. At the opposite end of the spectrum, **Australia** actually mandates that water harvesting is implemented for any remodeling or new construction in most Australian states. If you want more information on rainwater harvesting, I recommend **Harvest h2o.com** for doing further research. The final option is to hook up to utility/municipal water supplies. There is a cost involved, but unlike most of the other options above, the utility company is responsible for not only ensuring the reliability of the water supply to your tiny house, they are responsible for ensuring the safety of the water being supplied.

Hot Water Systems

Although a bracing cold water shower is an invigorating way to wake up in the mornings, very few of us enjoy that sort of shock to our system. In fact, I would be willing to say that that majority of us prefer to take hot (or at least warm) showers and baths, even in the dog days of summer. Humans have figured out many ways over the years of heating water. These range from a pot over a fire, to a kettle on a stove, to a tank style hot water heater, to a solar hot water panel, the lost goes on and on. i will touch on a few that people tend to consider when deciding how to heat water in their tiny houses.

Heating water over a campfire

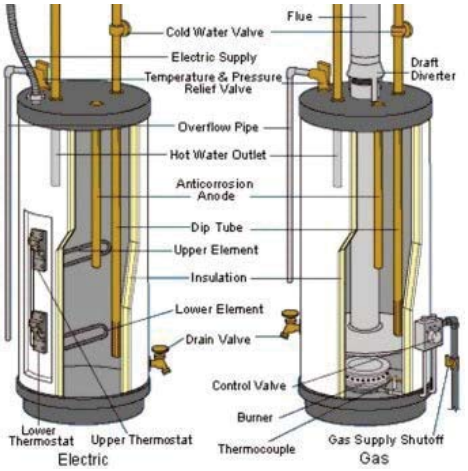
The most primitive is a pot heated over a fire. Just like with the jug of water above, this is the simplest method, but not necessarily the easiest. You are limited in the amount of water heated at one time by the capacity of the pot, and the time it takes to heat the water is limited by the amount of heat from the fire that is captured by the pot. There is also the matter of keeping the fire lit, and hot enough to heat the water in a short amount of time. There is also the drawback of weather and environment having an effect on the ability to heat he water efficiently. Is it windy? Then the fire's heat may be blown away from the pot, resulting in long heat times. Is it raining? The coolness of rain counteracts the heat building in the water, not to mention potentially putting out the fire, removing the source of heat. You can always bring the heat source indoors, heating water on a stove using a pot or kettle.

ZODI Outback Gear Fire Coil Water Heater

There are campfire heaters that are designed to capture the heat in the embers of a campfire and automatically channel it from a cold container to a hot water storage container. These are more efficient than a pot over a fire, and they do work well, but they still have the inherent drawback of relying on a campfire for heat, as well as being limited to the water volume in the supply jug. True, you can hook up a larger hot water jug and switch out supply jugs as they empty, or even hook the supply side up to your well water or utility water, But ultimately you are limited by the either the heating capacity of the fire, the storage capacity after the water is heated, or by the amount of water available to be heated. As you have probably figured out, to have usable hot water, you need four items:

- A supply of water to be heated.
- A source of heat
- A means to transfer heat from the source to the water
- A means to store the heated water

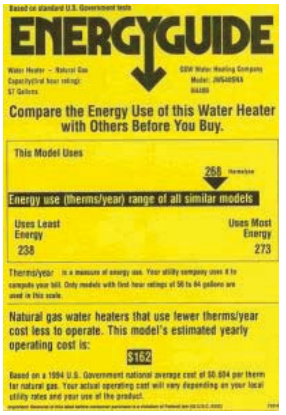
We touch upon the supply of water to be heated in the first section of this post. The source of heat can be a fire, the sun, a stove, a heating element, or a gas flame. We have touched on a camp fire as a heat source above. The transfer of heat typically occurs by means of a container being heated and transferring heat to the water. The storage of heated water is typically a tank, preferably insulated, and sized based on the inverse of how quickly the water can be heated. The Fire Coil water heater shown above makes it easy to see the basics of heating water. The water is fed at a slow rate to the source of heat in a container that allows the heat to be transferred, in this case the copper coil. You may think that if you increase the size of the copper tubing that you would increase the rate of hot water generation, but that is actually incorrect. The small size of pipe actually ensures that the water moves slowly enough that it has time to heat up while in the "heating zone". If you increased the size of pipe, more water would move through and at a faster rate of speed, which would actually mean each molecule of water would spend less time in the heating zone and therefore would end up not being as hot in the end. As you can see, there is a bit more to the science of creating a well performing water heating system. So let's delve into some of the other options that have been engineered to work well, starting with the standard style electric hot water tank.



Diagrams of Electric and Gas Tank Style Water Heaters

A standard tank style hot water heater consists of an insulated tank and one or more heating elements that are immersed in the water. For an electric heater, these are resistance elements, ie. elements that heat up when electricity is run through them due to the resistance of the material to the flow of electricity. Depending upon the size of the tank, there may be 1, 2, or even 3 elements within the tank. For gas heaters, there is a burner at the bottom which heats up the bottom of the water reservoir, then the hot exhaust gases flow up through the center of the tank, further transmitting heat as they pass through the tank, before heading up a chimney to the outside. Obviously, the size is dependent upon the amount of hot water that is needed, and the means used to estimate that amount is dependent upon the type of hot water system you wish to install.

This **page from the Department of Energy** explains how to estimate the size of the hot water heater you need by technology, but I will briefly recap the technique used for tank style.


ENERGYGUIDE
Compare the Energy Use of this Water Heater with Others Before You Buy.
This Model Uses
Energy use (therms/year) range of all similar models
Uses Least Energy
238
Uses Most Energy
273
Natural gas water heaters that use fewer therms/year cost less to operate. This model's estimated yearly operating cost is:
$162

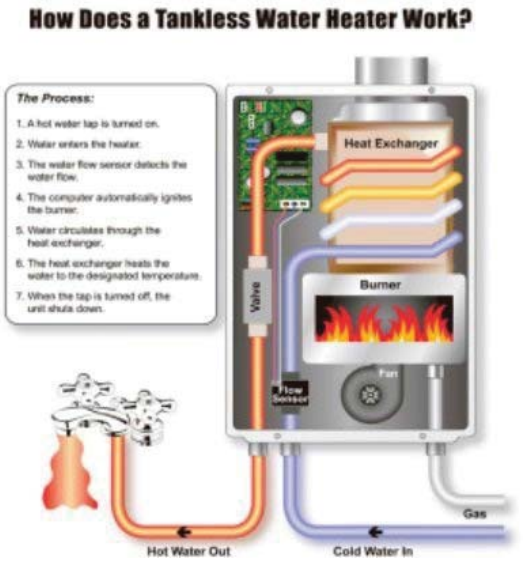
Sample Energy Guide Label for a Hot Water Heater

Look for the water heater's First Hour Rating. The first hour rating is the number of gallons of hot water the heater can supply per hour (starting with a tank full of hot water). The Energy Guide Label lists the first hour rating in the top left corner as "Capacity (first hour rating)." For the example shown to the left, it is 57 Gallons. You then need to estimate the peak hour demand that your tiny house will have. Peak Hour Demand is defined as the maximum demand in any one hour. Ie, determine what time of day (morning, noon, evening) you use the most hot water in your home. Keep in mind the number of people living in your home. Then using the chart shown below, add up the actual number of gallons that are used within that hour to estimate your maximum usage of hot water during this one hour of the day.

- Shower: 10 gallons avg.
- Shaving (0.5 gallons per minute): 2 gallons avg.
- Hand Dishwashing or Food Preparation (2 gallons per minute): 4 gallons avg.
- Automatic Dishwasher: 6 gallons avg.
- Clothes Washer: 7 gallons avg.

Reliance 6 20 SOMS K 20 Gallon Compact Electric Water Heater

So as an example, if your maximum use within 1 hour is 2 showers plus hand washing of dishes, the calculation would look like this: **2 x 10 gallons(showers) + 1 x 4 gallons (dish washing) = 24 gallons.** Once you know this First Hour Demand, you will want to match your hot water heater's rating to the demand. Too little, and you will run out of water before you are finished, too much and you are wasting energy keeping water hot. For future reference, the 6 gallon water heaters commonly referred to as point-of-use heaters, have a typical First Hour Rating of 8 gallons. For the hypothetical example above, you will most likely need a 20 gallon tank style heater. These take up to 24 x 24 x 26 inches worth of space, and weigh up to 230 pounds (the water alone is 162 pounds of that) when full.


How Does a Tankless Water Heater Work?
The Process:
1. A hot water tap is turned on.
2. Water enters the heater.
3. The water flow sensor detects the water flow.
4. The computer automatically ignites the burner.
5. Water circulates through the heat exchanger.
6. The heat exchanger heats the water to the designated temperature.
7. When the tap is turned off, the unit shuts down.
Heat Exchanger
Burner
Valve
Fan
Flow Sensor
Gas
Hot Water Out
Cold Water In

How a Tankless Heater works

For tiny houses, many people look to use a tankless style water heater. These work by flash heating the water as it passes through the unit. They choose them because they take up less space than a tank style, and weigh less since you are not storing a tank full of water. They are available in either electric or gas fired types. Both electric and gas work, but the gas fired types tend to be more efficient to operate. However, the gas versions require both intake air and a chimney/exhaust. Tankless water heaters are rated by the maximum temperature rise possible at a given flow rate. Therefore, to size a demand water heater, you need to determine the flow rate and the temperature rise you'll need for its application. First, list the number of hot water devices you expect to use at any one time. Then, add up their flow rates (gallons per minute). This is the desired flow rate you'll want for the demand water heater. For example, let's say you expect to simultaneously run a hot water faucet with a flow rate of 0.75 gallons (2.84 liters) per minute and a shower head with a flow rate of 2.5 gallons (9.46 liters) per minute. The flow rate through the demand water heater would need to be at least 3.25 gallons (12.3 liters) per minute. To determine temperature rise, subtract the incoming water temperature from the desired output temperature.

Unless you know otherwise, assume that the incoming water temperature is 50ºF (10ºC). For most uses, you'll want your water heated to 120ºF (49ºC).

In this example, you'd need a demand water heater that produces a temperature rise of 70ºF (39ºC) for most uses. For dishwashers without internal heaters and other such applications, you might want your water heated at 140ºF (60ºC). In that case, you'll need a temperature rise of 90ºF (50ºC).

Ecotemp L10 High Capacity Outdoor Tankless LP Water Heater

So for our example house, we will assume that we will wash dishes by hand, and have at most a shower and the sink faucet running at the same time. Our hypothetical sink faucet has a flow rate of 2.2 Gallons Per minute (GPM) and our hypothetical shower head has a rate of 2.5 GPM. This adds up to a maximum of 4.7 GPM. We are not needing to heat water for a dishwasher, so we can get by with a 70ºF (39ºC) temperature rise. Or we can decree that the house rule is that if someone is taking a shower, no washing dishes! This will drop our required flow rate to just the 2.5 GPM. Which means a tankless heater similar to the one to the right should suffice. Note that the one shown is designed to be mounted outside of the house. This allows you to avoid having to run a chimney through your envelope, and avoid having to worry about whether it is getting enough airflow. It also frees up space inside, since it is mounted outside. Of concern to tiny house users is that many tankless manufacturers state that their units are for use in a standard house, and that using them in a mobile application like an RV (or tiny house) will void the warranty, so read the warranty restrictions prior to purchasing. This is due to the internal elements not being designed to withstand a lot of vibration or bouncing, which could cause some of the units to get knocked out of adjustment when travelling.

Atwood XT 6 Gallon RV Water Heater

As always, the RV world has options available that may work for your tiny home. Specifically, a number of the RV water heater manufacturers have come up with a hybrid tank/tankless solution, that uses the operational concept of a providing a flow rate with having a small storage tank which effectively increases the available flow rate for a certain BTU output. These heaters are also compact, designed to fit into the spaces that traditional RV water heaters take up. A good version to consider is the Atwood XT line of water heaters. Like all RV water heaters, it is designed to be mounted into an exterior wall, as it exhausts to the outside through the cover (not shown). Some other options available for tiny homes are various types of solar hot water heaters, but those will have to wait for Part 2 - Waste Water Systems, Winterization, and Other Water Related Issues.

Tiny House Water Systems - Part 2 - Waste Water Systems, Winterization, and Other Water Related Issues

Waste Water Systems

Skara Brae by Wikipedia editor Wknight94

One of the common, yet often unspoken problems that we run into in tiny houses is dealing with our waste water. People have had to deal with waste water forever, and it has resulted in sewer systems known to have been built as far back as the Neolithic settlement of Skara Brae on the Orkney Islands in around 3180-2500 BC. So it is no surprise that Tiny Houses need to have some means of dealing with waste water.

Black Water and Grey Water

There are two types of waste water that need to be dealt with, commonly referred to as Grey Water and Black Water. The differentiating factor is the type of waste carried in the water. Black Water contains fecal matter, and typically originates in the toilet. Grey water does NOT contain fecal matter, and typically includes waste from the sink drains, from showers, and dishwashers. Standard plumbing systems combine both types and treat it the same, but there is a growing movement to

separate out the grey water and only send the black water into the septic or sewer system, using the grey water for purposes like watering the lawn, reducing the amount that needs to be treated by the septic system or the utility company. If you decide to go this route, there are a lot of **reference sources** out there to help, but the decision needs to be made in the early part of the design stage. You also need to verify with the local codes or health department as to what restrictions they impose on designing for the use of grey water. You don't want them to forbid you from using your system (under threat of fines) or make you rip it all out, redesign and rework it.

Yet as Lloyd Alter recently pointed out in an article in the **UK's The Guardian,** the way that we deal with Grey and Black water waste is inherently wasteful and, quite honestly, somewhat

unhealthy. It is an interesting read that may help inform your decision.

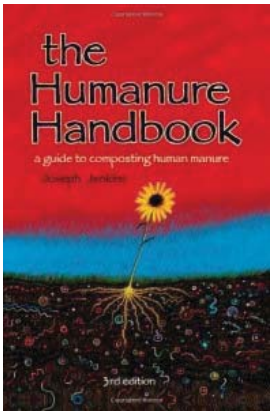
Toilet Options

Water closet, loo, throne room, outhouse, littlest room in the house, bathroom. All of these are synonyms for a private location in which to use the bathroom. there are a number of different options available to tiny house inhabitants, one of them will be right for you. The easiest to deal with is simply not to deal with it. Rather than allocating precious space in your tiny house for a toilet, you can always plan to make use of the toilet facilities in a nearby house or restroom. Many people have gone this route with successful results, but it is not for everyone.

Simplest option

The simplest to deal with is a sawdust composting toilet, based around two 5 gallon buckets. One bucket is used to hold dry sawdust, the other catches the waste. A nod to comfort is made by getting a pool noodle, cutting a slit in it, then

trimming it to fit. After using, you simply add a layer of sawdust to help contain the smell and start the composting process. It requires emptying on a regular basis into a composting bin set up outside, and proper care needs to be taken in dealing with the waste and composting process.



The Humanure Handbook 3rd Edition by Joe Jenkins

The best resource available on the topic is **"The Humanure Handbook" by Joseph Jenkins**. Joe began writing the book as a master's thesis while attending Slippery Rock University's Master of Science in Sustainable Systems program in the early 90's. The thesis adhered to the staid, dry (boring!) conventions of academic papers, which did not satisfy him, so he translated it into normal English that a typical person can understand and self-published it. Now on the 3rd edition, the concept has gained widespread attention and acceptance, and has been translated into 15 languages.

Of course, composting toilets need not be as basic as the option shown above. Joe also sells a starter kit through his website called the **Loveable Loo**.

Of course, you can also build your own customized version, which is limited only by your imagination as to the luxuriousness available.

Camping Toilets

Camco 41541 Portable Toilet - 5.3 gallon

Another option available is a camping toilet. These are normally square and blocky, having a holding tank beneath that will require regular emptying, and the more people using it will increase the frequency at which emptying is needed. Limited storage space you know. :-) There is no covering with sawdust required, as they normally have a trapdoor between the bowl and the holding tank which serves to limit the amount of odor that escapes. All of the above options are ones that allow your tiny house to be mobile. However, the RV market has come up with a solution that allows for larger capacities, which is to build in a larger holding tank beneath the floor with a drain used for emptying at a campground dump station. These are also typically sized to handle capturing all water waste from the sinks and shower.

Thetford Aqua Magic V RV toilet, designed to be mounted above a holding tank

A number of manufacturers make a toilet that is designed to mount above the holding tank, complete with a trap door mechanism and a water seal to help with odor control. The downfall of all of these portable solutions is that they need to be emptied on a regular basis. It can be in bucket increments, or in the rolling holding tank of a camp toilet, or in a built in holding tank that requires moving the tiny home to a dump station. However, the use of a built

in holding tank can allow for a semi-permanent connection to a sewer or septic tank, so long as you ensure a proper slope to the connection and make sure it can withstand the weather. The most convenient solution of course is to hook up to a septic system or a sewer system. However, this is a more permanent style of connection, (unless you hook up with a flexible RV style sewer hose) and limits the mobility of your tiny house. With a septic/sewer hook up, you are also able to use any style of household toilet that you like from a hardware/home improvement store. There are other toilet options available, such as incinerating toilets and many varieties of composting toilets all with different configurations, but the most common solutions are introduced above.

Winterization concerns

No, not this sort!

Unless you plan on building your tiny house in the tropics, say, underneath a palm tree overlooking a crystal clear lagoon, with the breakers softly shushing over the reef, while you snooze away in your hammock.. um, where was I? Oh yeah, UNLESS you build in a warm climate, you will probably want to consider ways to keep your pipes from freezing. Just like in a larger house, care will need to be taken to protect your water pipes lest you wake up one frigid morning unable to make your morning cuppa coffee. Unlike RVs and campers, which are typically used only during warm weather, most tiny houses are expected to be used year round. Like RVs and campers, it is harder to protect the pipes in a tiny house than in a regular house, because there is less to protect the pipes.

There are three main ways to protect pipes: Running water, Heat, and Insulation.

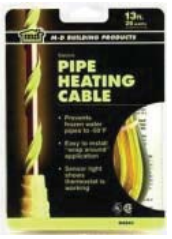
Running Water

Running water at sink

You often hear the advice that to keep pipes from freezing, you should crack open a faucet to let a small trickle of water to continuously flow through the pipes. Well, it does help, but in a hard freeze (defined as at least 2 hours of air temperatures below 26°F (-3.3°C) it guarantee results. The reason that it helps is that running water, by definition is not frozen, and by running a trickle through the pipes, when the water reaches whatever part at the highest risk of freezing. it does cool down, but it doesn't stay in that part of the pipe long enough to cool down enough to be an issue. Plus, it is always being replaced by new water at the warmer, supply temperature. For best results, most guidance on the matter states that the water stream should be as thin as possible to keep a constant flow of water, which should be about the diameter of a pencil lead. The downfall of course, is that this wastes water, to the tune of around 90 gallons a day per faucet! But, it does work.

Heat

Another way to keep pipes from freezing is through the application of heat. This can either be externally, by keeping them running through interior, heated spaces, or by applying heat to them via a heating cable, or internally, by running hot or warm water through the pipes by having a recirculating circuit.



13 ft pipe heating cable with auto thermostat

A heating cable basically is a linear resistance heater, designed to be wrapped along a pipe such that it looks similar to a candy cane. They typically have an indicator light that is lit when it is on, and the better versions have automatic thermostats so it will automatically turn on and

provide protection when the temperature drops below a set point. They work down to lower temperatures than just running water through the pipes, typically providing protection down to around -50°F (-45.6°C). At an average price in the U.S. of $0.1231 a Kilowatt Hour, a 13 foot cable would only use about 3 cents a day.

The aforementioned recirculating circuit basically consists of adding a return circuit to the plumbing with a small pump that allows you to constantly run water from a tank style hot water heater through the pipes and back to the tank. It works, but there is the added cost of the additional plumbing for the return run, the cost of the pump, the cost to run the pump, and the cost to slightly reheat the semi-cool water as it is returned to the water heater tank. Because of these costs, especially when compared to the nominal cost to run heating cables, these sorts of systems are not typically used for freeze protection. They tend to be used in higher end houses to ensure that there is instant hot water available when you turn on a faucet.

Insulation

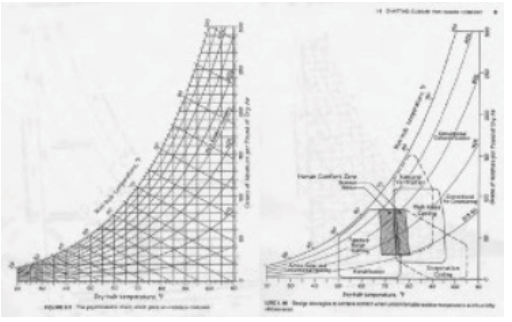
Foam Pipe Insulation, 4 pack of 3 foot sections

The other primary means of keeping pipes from freezing is to insulate them. this used to be done via asbestos sheathing, however as friable asbestos is NOT worth the health risk in case of inhalation of the asbestos fibers, this has been outlawed. Since then, the building products industry have come with the closed cell pipe insulation, which look like mini-pool noodles, split down the side, with double sided tape already applied to one side of the split so you can seal it around the pipe after slipping it on. They work by helping to keep the heat contained in the water in the pipe from escaping.

Of course, there are a number of other ways that you can deal with water systems, but I have tried to touch on the main ones that most tiny house people will chose from.

Tiny House Cooling Systems

Humans prefer to live within a certain range of temperatures. this is known as the human comfort zone, or alternatively, the thermal comfort zone. It is defined as the range of temperature, air movement, and humidity conditions that most people will find comfortable the majority of the time. Mechanical Engineers that design heating, ventilation, and air conditioning (HVAC) systems consider this so important to being able to do their work that they have developed ANSI/ASHRAE Standard 55 to be able quantify and specify what is required to ensure human comfort. The below chart is known as a psychometric chart, or human thermal comfort chart. This chart actually was developed through observations of conditions and surveys of actual people as they experienced them.



Psychometric or Human Comfort Temperature and Humidity Chart

Luckily, tiny home denizens don't really need to know how to read the above chart, as all it does is show the typical comfort zone in relation to both air temperature and humidity, although the chart on the right does show some ways that you can extend the comfortable zone by using moving air, or soaking up heat from the sun.

Which leads us to the two types of cooling, passive vs. active.

Passive Cooling

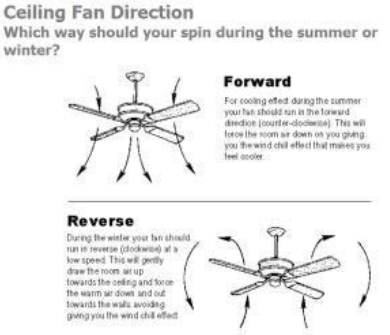
Passive cooling is cooling which does not require a fan or pump to cool you down. In other words, open a window! Now, this seems simple and it is! But there are some things to consider that will improve the efficacy as well as overall comfort when you crack them open.

One of the first is to ensure that you have cross ventilation. What this means, is that you have operable windows on both sides of your house, in locations where air that comes in one side can come out the other. In a full size house, many times interior walls get in the way of this, but in a tiny house, there typically are not as many walls to get in the way. The below diagram shows the typical ventilation schemes from good to best.

Schemes for ventilation

If we refer back to the psychometric chart at the top, you will see that increasing ventilation allows you to still be comfortable at higher temps and humidity. And what better way to increase ventilation than through the use of fans!

Ceiling Fans


Ceiling Fan Direction
Which way should your spin during the summer or winter?
Forward
For cooling effect during the summer your fan should run in the forward direction (counter-clockwise). This will force the room air down on you giving you the wind chill effect that makes you feel cooler.
Reverse
During the winter your fan should run in reverse (clockwise) at a low speed. This will gently draw the room air up towards the ceiling and force the warm air down and out towards the walls, avoiding giving you the wind chill effect.

Explanation of Ceiling Fan Direction

Ceiling fans seem to be the bane of modern interior decorators everywhere, and are the first thing torn out on all the design shows on HGTV and the DIY network. But a ceiling fan, when used properly, can save you up to 40% in the summer and up to 15% in the winter.

In the summer, it does this by creating a draft, cooling you through wind chill.

To maximize the effectiveness, you should use the faster speeds of your ceiling fan to move

more air across your skin.

In the winter, you want to slow the speed of the fan down, while at the same time reversing the direction. There are a couple of factors that make this the best option. First, heat rises, and in a still house, the air will stratify, or layer itself, with the hottest air being at the ceiling of a space and the coldest at the floor, which happens to be closest to the inhabitants.

Turning on a ceiling fan will de-stratify the air, pushing the heat at the ceiling down into the room to where the people are. However, the same wind chill effect that is put to good use in the summer is detrimental in winter, as you want to stay warm, not cool off. This is why you use the lowest speed of your fan in winter. You merely want to circulate the air, not create a cooling draft. This is also why you reverse the direction of the fan, because by pushing the air up against the ceiling, it pushes the hot air down the sides of the room, while at the same time diminishing the air speed of the moving air so that when it gets to you, it does not cool you.

Hunter 53091 Builder Deluxe 5-Blade Single Light Ceiling Fan with Brazilian Cherry/Stained Oak Blades and Piped Toffee Glass Light Bowl, 52-Inch, New Bronze

There are many, many styles and configurations of ceiling fans, able to match the decor of just about any taste, from tropical, to modern, to industrial. The primary considerations are the features of the fan in question. Do you want a light or not? Do you want a remote control? (They are actually very handy to have as, when you think about it, the fan is mounted way up there, and you are way down here, and the on-off chains are unsightly.) Also, the better brands are quieter and will last longer. Good brands include Hunter, MinkaAire, Emerson, and Casablanca.

Window / Floor / Desk Fans

Lasko 20 inch 3 Speed Box Fan

Window fans are also a time-honored means of ventilation. When the breezes outside aren't quite cutting it, make your own! There is the traditional box fan, whirring away in the window, providing a handy "robot voice" for the imaginative child. These work best when set up as exhaust fans (pointing out). They pull the air out of the house pulling fresh air in. If they are set up in a window that is higher up in the structure, with a window or vent closer to the floor open, then it exhausts the hot air out while pulling cooler air in, especially if used in the cooler, night time hours.

Rowenta Turbo Silence 4 Speed Pedestal Fan

Pedestal fans are also useful, in that they are larger than desk fans, and therefore can move as much air as a similarly sized box fan, while having the rotating function of a desk fan. Unlike a box fan however, they are designed to provide direct cooling by blowing air across the occupants. The rotating allows the breeze to be shared.

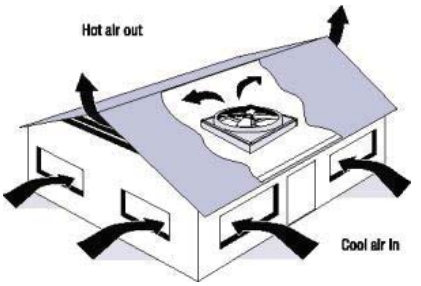
Desk fans are like Pedestal fans, only sized to fit on a desk or counter. Being smaller, they don't move as much air, and therefore are typically used for one person. They range from the cheap plastic types that you can pick up at Wal-mart, to high quality, well-built ones designed

to last a lifetime. You can find old ones from the early part of the century that are still running today from GE, Westinghouse, and Robbins & Myers. A decent version is made by Hunter. But you can find similar ones from many manufacturers.

Hunter 12 Inch Desk Fan

Ultimately, a fan is worth making room for in a tiny house, as its usefulness outweighs the space that it takes up. However, it is up to you to decide what style best matches your decor.

RV-style Roof Vent Fans

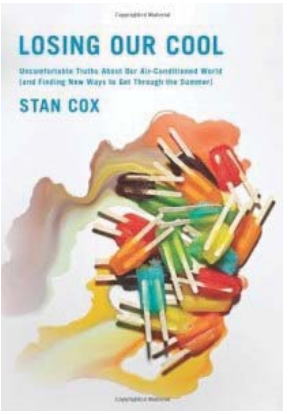


The RV Style roof vent fans work on the same principle as attic or whole house fans in a regular house. Capitalizing on the concept of hot air rising, a attic fan pushes air from the inhabited space into the attic, forcing the hot air in the attic out through the eave vents. And as the optimum time to use one is at night when it is cooler outside, the forcing of air into the attic draws the cool, nighttime air into the living space through open windows.

Fan-Tastic Vent 5000RBT PLR-WHT Vent with Reverse and Thermostat Polar

An RV vent fan is designed to be mounted in the roof, through a square hole. They can be used in a tiny house, but as with all penetrations in the roof, you need to be extremely careful with sealing and flashing. I recommend checking out the website of your roofing material's manufacturer for their recommended flashing and sealing details for skylights, as RV vent fans are technically the same, only smaller. Popular options for these fans are multi-speed motors, the ability to work in reverse, thermostats to control on/off functions, and even remote controls. The fan will have a hinged cover of typically smoked plastic that that is weather tight when closed.

Of course increasing ventilation is only effective to a point, as sometimes, it is just too humid, or too hot to matter. In those cases, most people consider an air conditioner a must.



Losing Our Cool by Stan Cox

However, there is an alternative stream of thought on the matter, in that some lay the increased rates of asthma and other respiratory ailments at the base of the prevalence of air conditioning in western society. For a thought provoking exploration of the topic, I highly recommend **"Losing our Cool" by Stan Cox**. As the blurb from Amazon states: LOSING OUR COOL SHOWS HOW INDOOR CLIMATE CONTROL IS COLLIDING WITH AN OUT-OF-CONTROL OUTDOOR CLIMATE. IN AMERICA, ENERGY CONSUMED BY HOME AIR-CONDITIONING, AND THE RESULTING GREENHOUSE EMISSIONS, HAVE DOUBLED IN JUST OVER A DECADE. IT ALSO MAKES A MUCH MORE POSITIVE ARGUMENT THAT LOOSENING OUR ATTACHMENT TO REFRIGERATED AIR COULD

BRING BENEFITS TO HUMANS AND THE PLANET THAT GO WELL BEYOND AVERTING A CLIMATE CRISIS. THOUGH IT SAVES LIVES IN HEAT WAVES, AIR-CONDITIONING MAY ALSO BE ALTERING OUR BODIES' SENSITIVITY TO HEAT; OUR RATES OF INFECTION, ALLERGY, ASTHMA, AND OBESITY; AND EVEN OUR SEX DRIVE. AIR-CONDITIONING HAS ERODED SOCIAL BONDS AND THWARTED CHILDHOOD ADVENTURE; IT HAS TRANSFORMED THE WAYS WE EAT, SLEEP, TRAVEL, WORK, BUY, RELAX, VOTE, AND MAKE BOTH LOVE AND WAR. THE FINAL CHAPTER SURVEYS THE MANY ALTERNATIVES TO CONVENTIONAL CENTRAL AIR-CONDITIONING. BY REINTRODUCING SOME TRADITIONAL COOLING METHODS, PUTTING NEWLY EMERGING TECHNOLOGIES INTO PRACTICE, AND GETTING BEYOND INDUSTRIAL DEFINITIONS OF COMFORT, WE CAN MAKE OURSELVES COMFORTABLE AND KEEP THE PLANET COMFORTABLE, TOO.

Mr. Cox makes some very valid points in the book, HOWEVER, even with the points brought up in the book, there are some discrepancies in Mr. Cox's arguments as well, especially from an engineering standpoint. With his agricultural geneticist background, Mr. Cox is very well qualified to discuss the pitfalls of corporate food and medicine, but his knowledge of basic energy theory is a bit lacking.

He makes the very common error of confusing power and energy; A kilowatt is a measure of power (the rate at which energy is produced or used); a kilowatt-hour is a measure of energy (a means of measuring the work performed through the consumption of energy) and you cannot interchange the two. A common analogy for watts and watt-hours is speed and distance. Speed is a rate of how fast you drive at an instant in time; distance is the length, or amount that you drive over a period of time. For example, if you drive at a constant rate of 60 miles per hour for one hour, then you will have traveled 60 miles. Similarly, if a 60 W light bulb is on for one hour, then that light bulb will have used 60 Wh of energy. If left on for two hours, then the 60 W light bulb will have used 120Wh of energy.

He also does not understand how the laws of thermodynamics as they relate to the refrigerant cycle of an air conditioner works, or the way that the electrical system in the U.S. works, confusing the efficiency of power generation at a central power plant as having anything to do with the efficiency of the refrigeration cycle itself.

One point that he does raise is very valid however, and that is that if you must condition the air in a space, it is better to condition a small volume (say the entirety of a tiny house), than to condition a large volume (such as a McMansion). So with that in mind, I will delve into some of the options available for conditioning the air through the use of active systems. (Which is a fancy way of saying, let's talk about air conditioners!)

Active Cooling

Air conditioners are rated in British Thermal Units or BTUs. A BTU is defined as the amount of heat energy needed to raise the temperature of 1 pound of water 1 degree Fahrenheit. For air conditioners, obviously, we are looking at how much heat can be removed by the unit, but the amount of heat energy is the same.

Many people buy an air conditioner that is too large, thinking it will provide better cooling because bigger is better! However, an over-sized air conditioner is actually less effective — and wastes energy at the same time. Air conditioners remove both heat and humidity from the air. If the unit is too large, it will cool the room quickly, but only remove some of the humidity. This leaves the room with a damp, clammy feeling. A properly sized unit will remove humidity effectively as it cools. Home Depot actually has a very good explanation of **how to choose the right size for your room (or tiny house)**, which I recommend consulting prior to deciding what you need.

As an example, an 8 x 16 foot tiny house is 128 square feet, however as most tiny houses have a loft area in them, I recommend adding 20% bringing it up to 152 square feet. Using the rules of thumb presented at the link above, this points to us needing 5,000 BTUs, but as our example tiny house has a kitchen in it, we need to add 4,000 BTUs, and for each person other than ourselves, we will need to add another 400 BTUs. So, for our example, if it is inhabited by 2 people, we will want a unit that has 9,400 BTUs in capacity. However, if you plan to have your tiny house in a shaded location (highly recommended) you will need to deduct 10% from the total, reducing it to 8,460 BTUs. You can round up if need be, but I would caution not to get too far from the calculated amount, and would actually recommend going down slightly to 8,000 BTUs for our example.

Window Units

LG LW8014ER Energy Star 8,000 BTU Window Unit

The cheapest option for air conditioning is a window style unit. It is also the most popular, as it is the easiest way to retro-fit a house or building to add air conditioning when the house or built was built without it. As such, there are many styles and options available, and many levels of efficiency. As we all want to save money, I highly suggest that you get a unit that is Energy-Star Qualified. You can get them with digital controls and remote controls, and of course multi-speed fans. Of course, you will need to plan for a place to put the unit, so it will help to consider this in the planning stages.

Through wall, Hotel-Style Air Conditioners aka. Packaged Terminal Air Conditioners (PTAC)

Amana 8,000 BTU PTAC

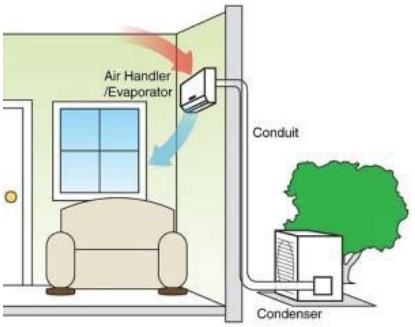
Another option available to the tiny house inhabitant is that of a Packaged Terminal Air Conditioner or PTAC. You may have never hear of the name or acronym, but if you have stayed in a budget hotel over the past decade or two, you have undoubtedly used one. Designed to be a self-contained unit that is mounted through the wall of the room typically beneath a window, these have the benefit of being a single packaged unit that includes a heat function. Although they were traditionally energy hogs, PTACs manufacturers have kept with the times and made them more efficient. The linked model from Amana also has the benefit of being made in America in a plant in Tennessee. PTACs require a wall sleeve to properly install them, so be sure to account for that if you go this route.

Roof Mounted, RV-style Air Conditioners

Dometic Brisk Air II 15,000 BTU AC with Heat (complete system)

The RV market has come up with their solution, which is to mount the AC unit on the roof. Like a PTAC, they are self contained and can contain a heat function in addition to the cooling. Because of the design of the compressor, they can only be mounted on a flat or mostly flat roof. If mounted at too much of an angle (greater than about 15 degrees), the compressor inside the unit will quickly burn out. Also, being designed for a RV application, they are designed for a roof cavity of 2.0 – 5.5 inches. They can be used with a small ductwork system to allow for air distribution, however the ductwork would need to be designed by a HVAC mechanical engineer for proper operation.

Mini-Split Systems



Ductless Mini Split Diagram

The final air conditioning solution I will cover is a solution that the U.S. is behind the rest of the world in adopting, that of the Mini-Split system. These are similar to a normal house sized split system, in that the mechanical workings of an air conditioner are split into two pieces, one designed to be installed inside the conditioned space (the Evaporator) while the other is to be mounted outside (Condenser), connected by refrigerant piping. The mini-splits are just, well, miniature versions of the full size, intended to cool (or heat) a single room rather than an entire house.

Pioneer 9,000 BTU 13 SEER Ductless Mini-Split AC with Heat

For tiny houses, some consideration must be made for mounting of the condenser on the outside of the tiny house, as well as a wall surface on the inside on which to mount the evaporator. Luckily, being smaller capacity, the two units are fairly small and compact, and the various manufacturers have designed their condensers to be wall mountable. As always, paying for a higher efficiency unit will be worth it, when you consider the energy savings over the life of the unit. The linked Pioneer unit is a good, well rated unit, typical of the category.

As you can see there are many cooling options available for tiny houses, and the best solution for one person may not be the best for another. Although some of the units mentioned have heating capabilities, the focus has been on cooling. I will expand upon heating options in the next Chapter, Tiny House Heating Systems.

Tiny House Heating Systems

At the time I am writing this in the United States, winter is nigh upon us. There is an El Niño that is expected to bring cooler and wetter temperatures to the lower half of the country, and warmer temperatures (relatively) for the upper tier of the country. As I try to wrap this post up, there is a massive blizzard walloping the Mid-Atlantic coast, expected to dump 2 + feet of snow in the Northern Virginia and DC area.

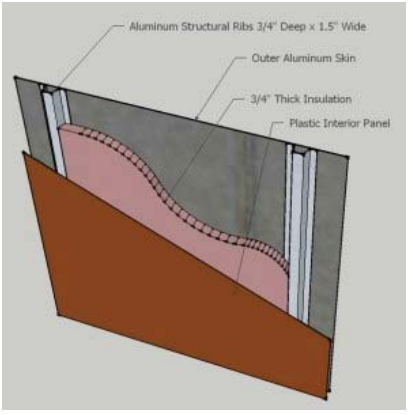
Luckily, a well-built tiny house provides a cozy, comfortable shelter from the elements, and is extremely cheap to heat. Unlike McMansions, where you can have central heat and air units equivalent in capacity to those needed for a mid-rise office building, tiny houses by virtue of their smallness, need less fuel, and thus less money, to keep warm.

Insulation

A poorly insulated roof example from Don Hynek's article "Snowy and Icy Indicators of Wasted Money"

The number one factor in reducing your heating bill is to make sure your abode is well insulated! **Don Hynek, writing in Home Energy Magazine**, covers the pitfalls of uninsulated roofs very well. Rather than trying to cover the same information (and probably not as well) I will link to his article instead. (link will open in a new window or tab)

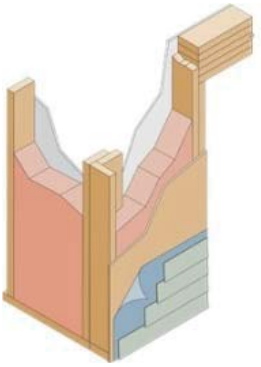
For those that don't feel like following the link, I will briefly summarize: Snowy conditions do a great job of showing which houses have poor insulation in their roofs. If a house has a solid, even blanket of snow, it is well insulated. If on the other hand, it has bare spots or even looks like the image above, that is a clear indication that there is little to no roof insulation present, and all of the heat in the house is escaping through the roof. The snow and ice at the edges of the roof are ice dams, which is where the melted snow refreezes once it hits a portion of the roof that is not over the uninsulated living / attic space, which will ruin your roof, and pose a hazard to people walking below if some of the ice breaks loose and falls.



Typical RV Wall Assembly

Aside from the aesthetics (looks) of a tiny house, insulation is one of the factors that sets a tiny house apart from RVs.

A typical RV wall looks like the one to the left. From the outside skin to the inside, you have an outside skin made of aluminium panels, 3/4" insulation (either spray or foil faced cellular), and an inside plastic interior panel. Total R value of around R5 to R6, if you are lucky. Rather than worry too much about how well insulated the RV is, the manufacturers try to minimize weight and expect the heating and / or air conditioning system to be over-sized to compensate.



Typical wood frame wall construction

A typical tiny house wall is built and insulated like a normal wood construction house wall. From the outside in, you have Siding, building wrap, sheathing, insulation, then drywall or panelling. The depth of the insulation is typically 3 1/2" inches, and the Total R value ends up being between R15 and R20 when using 2 x 4 lumber. Higher values can be achieved with use of more advanced building systems such as Structurally Insulated Panels (SIPS) and the like, but regardless, normal wood frame construction is at least 3 to 4 times more insulated than typical RV construction.

So, to recap the above, ensure that your tiny home is properly insulated, to include the roof. This is the first step in ensuring that your home is warm and cozy during the cold winter months.

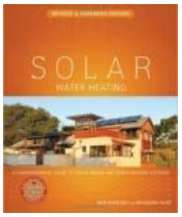
Active versus Passive Heating

There are two broad categories of methods that can be used to heat your tiny house. Active and Passive.

Active heating is what the majority of us are used to: a heating source that uses fuel of some sort that is consumed to generate heat. This can be a wood stove, an electric heater, a gas heater, or even a boiler of some sort providing hot water to a radiator.

Passive heating is a heating source that uses the warmth of the sun to heat your abode. It can range from just having windows that face the sun, to some sort of solar collector that captures the energy from the sun and converts it into heat used to heat water which is then piped into and used to heat the house using either radiators or under floor hydronic radiant heating, or a simple heat exchanger with a fan used to heat the air. The defining characteristic is that the heat used to heat the house is captured from the sun.

15 Tube Duda Solar Water Heater Collector 37° Frame Evacuated Vacuum Tubes SRCC Certified Hot



Solar Water Heating--Revised & Expanded Edition: A Comprehensive Guide to Solar Water and Space Heating Systems

I will not delve into how to design a passive heating system with this post, but if you want to find out more, I recommend **"Solar Water Heating--Revised & Expanded Edition: A Comprehensive Guide to Solar Water and Space Heating Systems" by Bob Ramlow.** It delves into how the systems work and how to maximize the sun's energy to heat water and your home.

Active Heating

Active heating systems are what most people think of when you start talking heating. I will further subdivide the category into what I will call "Direct" and "Indirect" systems.

Direct Active Systems

A Direct Active System is one where the heating of the house occurs as a direct result of burning fuel of some sort (or in the case of an electric heater, heating up an element). This can be a wood stove, a propane heater, or an electric space heater.

Wood Stoves

Vogelzang BX42E Boxwood Deluxe Cast Iron Wood-Burning Stove

Wood stoves are what many people think of when they think "rustic cabin heat". Whether it is a box style cook stove or a pot belly stove, these are American classics. Unfortunately, they tend to be polluting, as they do not burn the wood completely.

Napoleon 1100c Wood Burning Stove - Majolica Brown

Modern stoves include a catalytic converter, similar to what your car has, that helps to ensure that the fuel combusts fully. Aside from polluting less, it also makes the stove more fuel efficient, producing more heat with less fuel. This is not that important at the beginning of winter, when you have a full store of firewood laid aside, but will gain increasing importance as the heating season wears on, and your wood pile dwindles. The key is to look for an EPA certified stove.

Vermont Bun Baker Wood Cook Stove

Of course, if you are contemplating using a wood stove in a tiny home, you will appreciate multiple functions. In addition to heating, the stove to the right is a cook stove and includes a small oven. There is even an optional water heater attachment available for the stove.

Other options include pellet stoves. These are wood stoves that use compressed sawdust pellets for fuel as opposed to wood logs.

Pleasant Hearth Medium 35000 BTU's Pellet Stove with 40-Pound Hopper

Rather than hand loading split logs into the firebox, a wood pellet stove stores the pellets in a storage hopper and has an automatic feeder that meters the pellets into the firebox at an optimum rate for maximum efficiency. A full hopper load can often last for up to a day or more of continuous burning time. The drawback to pellet stoves however is that they will only use wood pellets, so if you run out, you have to purchase more pellets. Cutting down a tree to feed it is not an option.

Gas Heaters

Just like with larger houses, gas heat is a good option, especially if you plan to use gas to cook as well. There are two forms commonly available, natural gas and propane.

Natural gas is the gas provided by your utility through a buried hard line. To connect to the system, you have to of course, set up an account with the gas company, and have any connection to their system made in accordance with the National Gas Code by a licensed tradesman, and the connection will be inspected by the gas company prior to their approving the connection.

The more common option for tiny houses is Propane. This is because of the portable nature of it, as it is supplied in refillable bottles, ranging from the 15 or 20 pound bottles used for your gas barbeque grill, to 200+ pound tanks set up semi permanently by the gas company.

Mr. Heater F232000 MH9BX Buddy 4,000-9,000-BTU Indoor-Safe Portable Radiant Heater

The smallest and least efficient version of a gas heater is the common camp heater. These small, portable heaters are designed to be hooked up to a camp bottle of propane, but can be easily adapted to hook into a larger bottle or tank.

Many people opt for heating technology used by the boating community.

Dickinson Newport Propane Direct Vent Heater

Manufacturers such as Dickinson Marine have been making high quality, stainless steel heaters and appliances for the marine market since the 1930's. These are extremely high quality, designed for mobile applications, and for tougher environments than most tiny houses will ever see.

Mr. Heater Corporation Vent Free Flame Propane Heater, 30k BTU, Blue

Another option is the blue flame, vent-less propane wall heaters that are common (at least in the South) in rural areas. These work by the flame heating up a ceramic brick, which actually provides the heat radiantly to the space. These are a valid option, but be aware that they release water vapor into the living space, which may not be a good option for a tiny house, especially since most tiny houses are very air tight. This can cause condensation issues inside the house, and ultimately could cause rot.

Electric Heaters

Electric heat is an option for many tiny houses, especially if they do not plan to use gas for cooking. Options range from the inefficient resistant radiant heaters, to more efficient ceramic heaters, to the most efficient quartz infrared heaters. However, be aware that electric heat is typically the most inefficient option available.

Comfort Zone CZ550 Comfort Zone Heater

Electric coil heaters work essentially by running an electric current through a thick wire, which heats up due to resistance. A reflector placed behind the heating elements helps to reflect the heat out into the space. They are rated by the number of Watts they require to operate, and are typically used as personal space heaters, due to the power requirements.

Comfort Glow BDISC6 Ceramic Disc Furnace, 5200 BTU, Brown

Ceramic style electric heaters work similarly, except that the heat generated heats up a ceramic element, while a built-in fan blows air across the element heating the space. Again, the size is typically limited by the power draw of the heater.

Comfort Zone CZQTV5M Ceiling Mount Quartz Heater ,Black, 1500 Watts

Infrared heaters work by heating an element that gives off infrared rays rather than just heat. You probably have encountered them at the entrance to big box stores, where all of a sudden you feel warmth on your skin, despite the coolness of the surrounding air. These work by heating the surfaces that the infrared rays hit, not by heating the air itself, which makes them more of a spot heater than an area heater. However, you could aim the heater at a stone or ceramic surface, such as a counter top. This would heat up the surface, which would then heat the air in the space.

Global Air GD9315BCW-5 Large Room Infrared Quartz Heater with Wood Cabinet and Remote Control

There are cabinet style and table top style infrared heaters available as well, which look a bit more subdued, but work the same way.

Kerosene Heaters

Dura Heat, DH2304, Convection Kerosene Heater, Portable, Indoor, 23,000 BTU

Another option is to use a kerosene heater. Kerosene is an oil distillate, similar in its heat of combustion to diesel fuel. It is one of the oldest forms of oil product used for heat and light, having been written about by the Persians in the 9th Century. It can be derived from crude oil or coal, but ultimately, it is useful as a heating fuel that can do double duty as a light source if you have a kerosene

lantern, albeit a dangerous one: In 1880, close to 40% of all fires in New York City were due to faulty kerosene lanterns, not to mention, a kerosene lantern is THE way to start a barn fire if movies and TV are to be believed.

As a result of the safety issues, many states and jurisdictions have banned the use of kerosene heaters for residential use. However, with proper care in the storage of the fuel, in refueling the heater, the care and maintenance of the heater, and in the operation of the heater, a kerosene heater is definitely a viable heat source, where available, that can do double duty as a stove in a pinch by heating food in a pot placed atop the safety cage (though the manufacturers advise against such use).

Indirect Active Systems

An Indirect Active System is one where the heating of the house occurs through an indirect method, where the heat from the burning of the fuel is captured in some fashion and sent to the living space via a transport medium of some sort such as refrigerant, water, or even air, where the heat is then pulled out of the transport medium and used to heat a space.

Electric Oil Filled Radiator

Many would consider this type of heater to be a direct active system, as you plug it in, it heats up, and you have heat for your room, all from one relatively compact unit. However, this heater is definitely an Indirect heater, as I will explain.

DeLonghi TRO715L Safeheat 1500W Basic Portable Oil-Filled Radiator - Light Grey

An electric oil filled radiator consists of a metal container filled with some sort of oil (usually mineral oil) with an electric heating element immersed in the oil. It works by the heating element heating the oil up which then releases the heat through the metal container to heat the air. These heaters are actually more efficient than the smaller electric space heaters, as they do not require a fan to blow air across the heating element. Instead, they rely on the natural convection of air in a space, along with the heat retention capacity of the oil to get by with a smaller heating element for the same effective BTUs.

Mini-Split System

Pioneer 9,000 BTU 13 SEER Ductless Mini-Split AC with Heat

A mini-spit system is a heat pump sized for a single room or small house. These were covered in my **tiny house cooling systems post**, but I mention them here because, like the

heat pump system in a larger house, they can be essentially run in reverse to dump heat into a space as opposed to pulling it out of a space. This double function from one unit is very appealing in a tiny house, as it keeps you from having to buy a separate heating and cooling solution.

Window Unit with Heat Option

Frigidaire FFRH0822R1 8000 BTU 115-volt Compact Slide-Out Chassis Air Conditioner/Heat Pump with Remote Control

Again, window units were covered in the tiny house cooling systems chapter, however I mention them here as some versions do have a heat option on them. the lower end versions essentially have an electric heating element in them making them just a glorified electric heater, while the higher end versions are heat pumps and can be reversed to pump heat into a space rather than pulling it out. Honestly, I recommend against the version with the electric heating element, as for the price, you can get a better air conditioner and a better electric heater. But the shown heat pump version is decent.

Hot Water (Hydronic) Heating

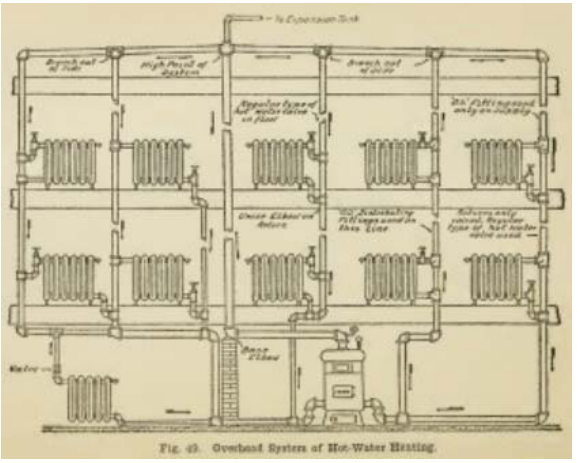
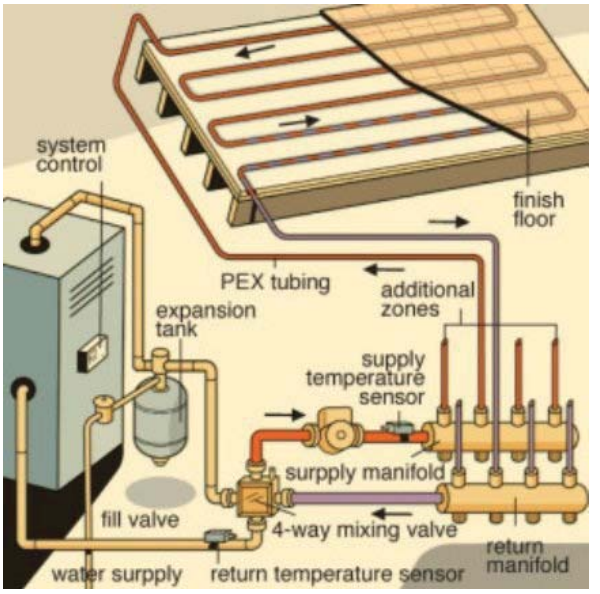


Fig. 49. Overhead System of Hot-Water Heating.

Radiator Heating Diagram

One option that many tiny housers have not considered is the use of hot water to heat their houses. Traditionally, these were used in large houses and buildings that had a boiler in the basement. The boiler heated up the water, typically turning it into steam, which it then distributed to radiators throughout the building. The radiators transferred heat from the steam into the rooms, and in the process condensed the steam back into water, which was routed back to the boiler to start the process all over again. This system can also be modified to use hot water instead of steam.



Water Source Radiant Floor Heating Diagram

A form of this concept has been used in the modern era for radiant floor heating. The water is heated by a boiler, and mixed with the cooled return water before being sent through loops of tubing beneath the floor of a house. Unlike a forced air heating system, which heats air (which is a poor medium for transferring heat) and then blows it into the space, a hydronic system heats the floor surfaces in the space, which then radiate the heat outward, heating the space and occupants. This also keeps the heat down where it is needed, as opposed to fighting against the natural propensity for hot air to rise.

Either of these systems can be adapted to a tiny house, with a little out of the box thinking. If you are using a tank style water heater, you can use that in lieu of the boiler in either of the systems above. This is only possible because tiny houses are, well, tiny. The boiler based systems are sized to heat an entire house or building, whereas the heating requirements of a tiny house can typically be handled by a small hot water heater. It is especially efficient if rather than using electricity or

gas to heat the water, you use a hot water solar collector to heat the water, as a the sun can provide all of the heat you need, and then some. Consult a professional with experience with sizing hydronic heating systems for more information.

Electric Underfloor Radiant Heat

An alternative to the Water Source Radiant Floor Heat is Electric Radiant heat. Essentially, this is a wire that is inefficient in conducting electricity and as such heats up. This process is known as resistance heating. Commercial greenhouses will often use this sort of resistance heating in a sand bed upon which newly planted seeds or cuttings are placed, to allow for propagation of plants in winter. It is also the same concept as the electric resistance heater mentioned above, but the heating element is insulated to protect it and adjacent materials from each other.

It is more efficient than the electric resistance space heater, in that the intent is to use the heating cable to warm the floor surfaces, rather than air, but a drawback is that the cable is relatively fragile, and rendered useless if broken, which can occur from an errant screw or nail, or inadvertent crimping during the install of the finished floor surface.

Normally, If someone is considering underfloor radiant heat, I point them to the water source type. HOWEVER, there is one electric radiant floor heating technology that I do recommend. This is the **STEP warmfloor system**, which rather than using a cable that is looped under the floor surface, uses a resistance mat that is waterproof, can be punctured / nailed/ screwed/ stapled through with no detrimental effect, and spreads out the heat more efficiently due to its larger surface area. It can be installed under pretty much any flooring surface (tile, wood, carpet, concrete) or even encapsulated in epoxy as shown below.

Another benefit is that the system is 24 Volt and can be directly powered by wind or solar PV. Of Particular interest to the Tiny House market, the company offers their **STEP RV** product, with a higher output wattage that the standard residential element, to help counteract the typical higher energy losses inherent in RVs. Of course, your tiny house should be better insulated than an RV, so the standard system should be perfectly adequate, but it is nice to have the option.

Backup Systems

From experience, I know that having some form of backup heat available is always good to have. You may run out of fuel for your heater, or the electricity may go out from where a limb fell on a line somewhere. As such, I always recommend that people have some sort of alternative heat available to them. It doesn't need to be capable of replacing your primary source of heat BTU for BTU, rather it merely needs to be capable of keeping your plumbing (and you) from freezing on the coldest night of the year. As such, I recommend that people figure out what sort of alternative heat source meets their needs, both heat wise and storage space wise. Ultimately, you do not want to have to resort to turning your oven / stove burners on to provide emergency heat. It is dangerous, wasteful, and quite honestly only marginally effective.

I hope the above discussion has provided the needed fuel to power your decision as to what sort of heat you will use in your tiny house, and above all, serves to keep you cozy and warm.